

First impressions: A preliminary study of domestic dog puppies' responses to verbal cues issued by an artificial agent

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ABSTRACT

Domestic pet dog puppies (hereafter puppies) typically co-exist and develop within a technology-rich environment, spending a large amount of time in the home. An audio/ food dispensing automated device (an artificial agent, hereafter agent) was evaluated for enrichment potential. The agent issued pre-recorded owner-spoken verbal cues to puppies and food rewards for their correct behavioural responses. Puppies' latencies to look up at the agent after it spoke their name, the word 'hi', and dispensed food rewards, and their abilities to respond correctly to its cues were measured. Welfare during interaction was examined using quantitative continuous behaviour sampling. In the first of two conditions, puppies ($n = 8$) were observed responding to verbal cues issued by the agent, with researcher and owner present (A+RO). The agent was remotely triggered to call each puppy by name and issue the cues 'sit' and 'down' in a repeated, randomised order totalling eight cues per puppy. In a baseline condition for comparison (owner, with researcher and agent present) (O+RA) the owner replaced the agent's role. Attentional focus (looking up at the agent with direct eye contact) was achieved following the agent speaking the puppies' names, the word 'hi' and dispensing food rewards ($M = 33$ sec). In the subsequent two test conditions, no significant difference in puppies' correct first choice behavioural responses to cues issued by the agent versus owner was found ($p = 0.609$). Significantly longer response latencies to cues in the agent versus owner condition were revealed ($p = 0.001$). No significant differences were found in state behaviours 'looking up' ($p = 0.069$), 'cued response behaviour' ($p = 0.12$), 'eating food rewards' ($p = 0.263$) and 'close proximity post-test' ($p = 0.612$) between conditions. A significant difference was found between the two conditions for 'tail wag bout', greatest in O+RA ($p = 0.028$). Puppies responded correctly to the agent's cues during their first exposure to this novel paradigm and indicators of motivation to interact were identified throughout testing.

1. Introduction

Audition in puppies is developed by four weeks of age (Scott and Fuller, 1965). The sensory organs and neurological system begin to mature, and puppies are responsive to sounds, visual stimuli and sudden movements (Lord, 2012). Puppies as young as nine-weeks old are curious about and attentive to dog/ puppy-directed human speech (Fonseca et al., 2023) and can identify the source when emitted from a speaker (Ben-Aderet et al., 2017). They are able to use the sound of food being placed into a bowl to locate it (Bray et al., 2020) and can use human speech (unimodally) as a reference to the source of food without pre-conditioning (Rossano et al., 2014). Puppies well-socialised with humans outperformed adult dogs in Rossano and colleagues' study, suggesting that the salience of auditory cues may decline over time as

adult dogs typically become accustomed to human-centric visual cues (e.g., hand signals) or other multimodal information (Rowe, 2005). Given these findings, it is perhaps unsurprising that puppies are able to be conditioned unimodally to respond to human verbal cues in the context of obedience training.

Positive reinforcement training (PRT) is a form of cognitive enrichment (Riley, 2018; Shaw et al., 2022); the affordance of appropriate problem solving/ learning opportunities resulting in measurable positive welfare outcomes. PRT in adult dogs has resulted in attentiveness to owners (Deldalle and Gaunet, 2014), strong dog-owner bonds (de Castro et al., 2019), better performance at novel training tasks than dogs trained using aversive methods (Rooney and Cowan, 2011), positive cognitive bias (Casey et al., 2021) and experiences of pleasure (Shaw et al., 2022). Rewarding events occurring throughout PRT are

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underpinned by acute positive anticipation, arguably the key component of pleasure (Sapolsky, 1994; Schultz, 2015; Mellor, 2019). Craig (1918) framed anticipation within a *pleasure cycle*, representing dopamine dependent anticipatory ('wanting'/positive reward seeking), consummatory ('liking') and satiety (learning) phases aligning with PRT sequences when food is the reinforcer (Cabanac, 1992; Berridge and Kringelbach, 2011). Studies of adult dogs have recorded tail wagging, speed of approach, focus on the source of cue/ reward and correct behavioural responses to cues as indicators of positive anticipation, and measures of motivation to obtain food rewards in both the presence and absence of humans (McGowan et al., 2014; Travain et al., 2016; Riemer et al., 2018; Bremhorst et al., 2019; Cameron et al., 2019). In adult dogs, Shaw and colleagues (2022) revealed that an artificial agent was able to simulate key components of the human role (verbal cue-reward) during PRT, finding no significant differences in performance or indicators of positive welfare between agent- and direct owner-dog interaction.

Indeed, cognitive enrichment studies typically examine animals' interactions with automated/ operant devices which augment, mimic or circumvent direct human-animal interplay (Riley, 2018). While such literature is sparse and sample sizes small, both acute, short-term (e.g., Hagen and Broom, 2004; McGowan et al., 2014) and longer-term positive welfare outcomes have been revealed across species. In their seminal study, Ernst et al. (2005) trained domestic pigs ($n = 8$) using classical and operant conditioning to approach an automated feeding station (CFS) upon identifying their individual, auditory 'call tone', and later to push a button at the CFS to release food. Over time, successful task learning, consistent, voluntary approach to the device, correct performance, increased exploratory behaviour, and decreased fearful behaviour was reported. The authors concluded frequent, brief positive challenges may be a suitable means to mitigate boredom, and thus improve welfare.

The affordance of positive challenges to young, developing individuals is thought to improve cognitive performance in the longer-term (Diamond, 2013; Gawdat, 2021). Foraita and colleagues (2021) suggest that small, age-appropriate challenges during puppyhood and throughout life might advance executive function, particularly behavioural inhibition. For dogs living within the human environment, behavioural regulation is a critical factor for harmonious partnerships, encouraging focus and the ability to meet novel, unanticipated future challenges (Olsen, 2018).

Previous studies (Shaw and Riley, 2020; Shaw et al., 2022) provide a rationale for investigating the potential of an audio/ reward dispensing agent as cognitive enrichment for puppies. Shaw and colleagues tested the ability of adult dogs to respond correctly to multiple, randomised owner-spoken and previously trained verbal cues issued by the agent. Dogs were provided a stepwise familiarisation-to-agent phase prior to testing; an ecologically valid step to best mitigate any potential indicators of negative welfare in response to the novel paradigm. No significant differences were found between dogs' correct first choice behavioural responses to cues issued by agent or owner directly, and multiple behavioural indicators of positive welfare were not significantly different between conditions. It was suggested however, that the sample may have been primed for success with the agent given their life histories of PRT with food as the reinforcer. It was also suggested that the familiarisation phase may have been unnecessary; dogs could potentially respond to the agent's cues following a brief introduction.

The current preliminary study therefore, repeated methodological elements of Shaw et al. (2022). The ability of a small sample ($n = 8$) of puppies to respond correctly to two previously trained cues ('sit' and 'down') issued in a repeated, randomised order by the agent and by owners directly for comparison was measured. Puppies were not afforded a familiarisation-to-agent phase, rather the agent spoke to each puppy (said their name, the word 'hi' and dispensed food rewards) as they entered the test room, to attract their attention. Puppies' first exposure to verbal cues issued by the agent occurred subsequently during the testing period. Welfare was measured in both conditions

(agent-interaction and owner-interaction) using quantitative behavioural sampling. The aim of the study was to assess both cognitive abilities and welfare outcomes of agent-interaction in puppies with by default, minimal PRT and life experiences.

2. Materials and methods

2.1. Ethics statement

Ethical approval was obtained from the Ethics Committee, University of Winchester, UK, approval.

number: RKEEC210702_Shaw.18 and the study follows the ethical guidelines published by the Association of the Study of Animal Behaviour (ASAB). Owner and puppy participation was voluntary.

2.2. Animals

Eight puppies (two females and six males), age range 14–22 weeks (mean age 16.6 weeks), of various breeds (four pure breeds and four mixed breeds) were studied. Criteria for inclusion were as follows: 1. good physical health, 2. reliability of recall to owner and 3. reliability of two behaviours, 'sit' and 'down' on verbal cue trained using PRT with food as the reinforcer. Prior to participation, all owners confirmed via enrolment forms that these criteria were met. Purposive sampling was applied to recruit puppies from the researcher's private puppy school where inclusion criteria were confirmed by the researcher. Puppies were tested mid-way through their five-week course, hence reliability of 'sit' and 'down' on verbal cue was newly conditioned.

2.3. Cognitive test materials and methods

2.3.1. The agent, controlling equipment and video cameras

The agent (Figs. 1–3) as detailed in Shaw and Riley (2020) and Shaw et al. (2022) comprised a modified wireless remote-controlled treat dispenser containing sliced Nature's Menu Puppy® food training rewards (every puppy received the same rewards); Bluetooth® Denon® Envaya wireless speaker (for issue of pre-recorded owner spoken cues) and GoPro® Hero 4 video camera. When in use, the agent was remotely controlled by the researcher via a MacBook Pro® computer using GarageBand® (to record owner cues) and Apple Music® (to play back and repeat cues) applications. At other times it remained silent in the room.

2.3.2. Test facilities

The test facilities comprised a large room (Fig. 2). A desk was placed three metres away from the agent; in condition A+RO (agent, with researcher and owner present), the researcher and each puppy's owner were seated at the desk, facing the agent, with the puppy's back to them. This best ensured that puppies were not looking at their owners/



Fig. 1. The agent (Shaw and Riley, 2020; Shaw et al., 2022), comprising modified commercial remote controlled treat dispenser, camera and speaker.

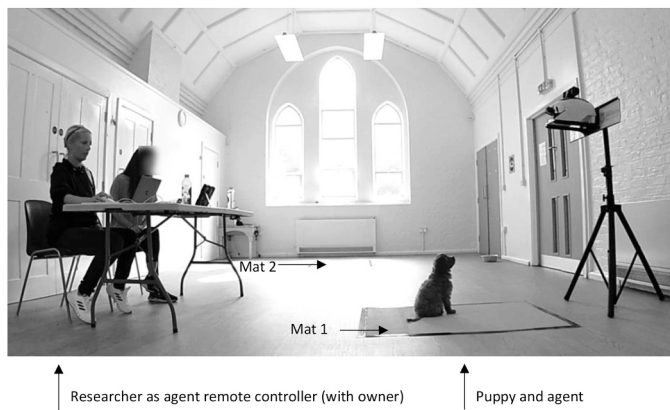


Fig. 2. Condition A+RO. Test facilities showing test room, apparatus layout, puppy, owner and researcher.

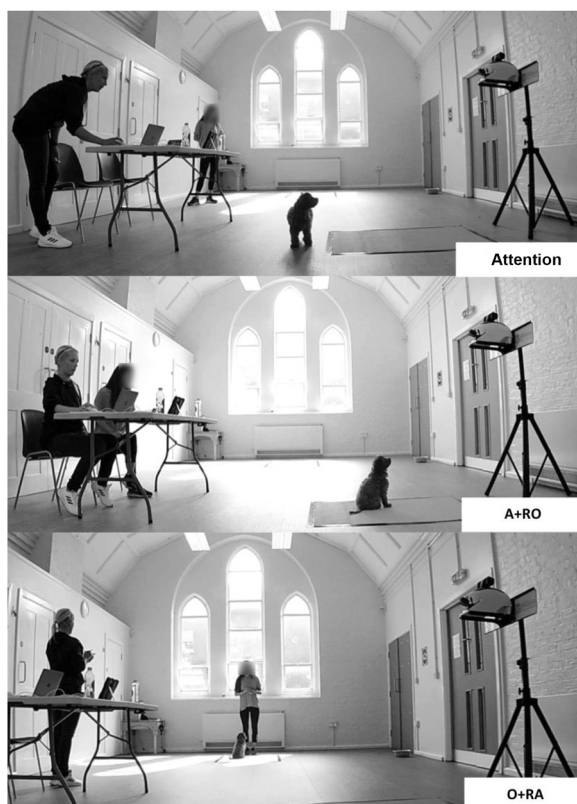


Fig. 3. Agent attracts puppy's attention, and puppy performing one of eight cues issued ('sit'), in each of the test conditions, A+RO (agent, with researcher and owner present); O+RA (owner, with researcher and agent present).

receiving visual or verbal feedback. The desk remained in place throughout testing, from where the researcher remotely controlled the agent. Two mats were placed on the floor, one directly in front of the agent and another four metres to the left of the desk for owners to stand behind during baseline (O+RA; owner with researcher and agent present). The mats best ensured puppies' comfort and standardised their approach distances at the start of each test in both conditions. Fresh water was provided in a bowl on the floor of the test room, accessible at all times during testing.

2.4. Cognitive tests: Experimental design and procedure

Each puppy-owner dyad attended one testing session, with a

maximum duration of 30 min. Puppies were tested individually; owners participated in the two experimental conditions: 1. Agent, with researcher and owner present (A+RO) (cues issued by the agent with owner and researcher in the test room) and 2. Owner, with researcher and agent present (O+RA) (baseline) (cues issued by the

puppy's owner directly with researcher and agent in the test room). These conditions allowed for comparisons of behaviour between agent vs owner interaction and were provided in the same order for all puppies.

2.4.1. Agent attention phase

Each puppy and owner entered the test room, and the puppy was let off-lead to investigate the room for ~two minutes. The researcher informed the owner that the agent would imminently 'speak' the puppy's name, say 'hi' and dispense food rewards. If the puppy showed indicators of negative welfare as observed by the researcher, the trial would be terminated. The researcher had used her own voice to pre-record each puppy's name and the word 'hi' (e.g., 'Winnie, hi') into the computer for agent playback. This method enabled puppies to enter the test room and the agent to speak to them without the time and interference of recording owners' voices and playback testing. As the researcher herself recorded all of the puppies' names for playback, this element of the experiment was standardised. The owner was free to stand wherever they preferred in the room (but not in close proximity to the agent) during this phase and to observe their puppy. The researcher triggered the agent to issue the two words and dispense food rewards. When the puppy approached the mat in front of the agent and consumed the food rewards, the researcher triggered the same words again from the agent and food rewards; only these two words were issued during this attention phase. This was repeated as many times as necessary until the puppy looked up at the agent with direct eye contact; the researcher triggered the agent to dispense food rewards for this behavioural response. Immediately following this response, the researcher requested the owner to sit at the desk next to the researcher, the puppy was free once more to explore the test room. The researcher asked the owner to speak their recall cue (e.g., 'Winnie come') and two verbal cues ('sit' and 'down') individually into the researcher's computer for recording. After these recordings were complete, the researcher asked the owner to call their puppy to sit by their side at the desk, the owner gently held the puppy's collar or harness to keep them in a stay before the test phase was initiated.

2.4.2. Test phase: Conditions A+RO (agent-interaction), O+RA (owner-interaction)

Following the attention phase, tests were recorded in the two conditions described. In each condition, puppies were called to the agent or owner (depending on condition) and approach was voluntary; puppies could not be forced to approach. Following a successful approach, puppies were issued the 'sit' (A) and 'down' (B) verbal cues (all puppies were issued the same cues) in a repeated, randomised order not previously given (to the researcher's best knowledge). The order of issue was the same for every puppy: A-B-B-A-A-B-B, in both conditions. The specific procedure in each condition was as follows:

2.4.2.1. Agent interaction; researcher and owner in the test room (A+RO). The researcher advised the owner to remain seated at the desk throughout this condition and not to interact with the puppy in any way, visually or verbally, including giving eye contact. With the owner, researcher and puppy stationed at the desk, approximately three metres away from the agent and facing it, the researcher triggered the recall cue from the agent; the owner let go of the puppy's collar/ harness. If the puppy did not approach the agent, the recall cue was triggered again, up to five times maximum. When the puppy arrived at the agent, the researcher triggered the agent to dispense rewards. When the puppy finished eating the rewards and was in front of the agent (but not

necessarily looking up at it), the researcher triggered the first verbal cue. When the puppy responded correctly, the researcher triggered the agent to dispense rewards. If the puppy did not respond or responded incorrectly, the cue was issued up to a maximum of four further times. Only correct behavioural responses were rewarded with food. If the puppy did not respond correctly by the fifth iteration, a fail was recorded for that cue. When the puppy finished eating the rewards after a correct response, the researcher triggered the second verbal cue, applying the same protocols as in the first verbal cue. This was continued until all of the cues in the set randomised order had been issued. Immediately after the last food rewards had been consumed by the puppy, a one-minute period of silence (no further agent cues being issued) was applied to observe puppies' length of stay in front of the agent (on the mat specifically) when it was no longer in operation. The researcher and owner remained silent during this period.

2.4.2.2. Owner interaction; researcher and agent in the test room (O+RA). Following completion of condition A+RO, the researcher requested that the owner approach and stand behind the second mat to the left of the desk. The researcher knelt approximately three metres away from the mat, facing it, and gently restrained the puppy by collar or harness; the puppy was facing the owner; the agent was situated to the puppy's right side. Facing the puppy and standing static without eye contact, the owner gave their recall cue; the researcher let go of the puppy. When the puppy arrived at the owner, food rewards were thrown onto the mat from the owner's hand. Rewards were the same as those issued by the agent. With the puppy in front of them (facing them but not necessarily looking up) and while remaining static with no eye contact, the owner gave their first verbal cue. Eye contact or hand gestures were not permitted to ensure that cue delivery was unimodal and to enable comparisons of responses between the agent and owner conditions. A correct response was rewarded with food thrown on the mat from the owner's hand. If the puppy did not respond or responded incorrectly, the cue was repeated by the owner up to a maximum of four further times. Only correct behavioural responses were rewarded with food. If the puppy did not respond correctly by the fifth iteration, a fail was recorded for that cue. The owner gave their subsequent verbal cues as the agent had in the previous condition, in the same order, and each correct response was rewarded in the same way. The researcher instructed the owner as to which cues to give by standing behind the puppy (out of the puppy's sight) and giving hand signals for either 'sit' or 'down'. Immediately after the last food rewards had been consumed by the puppy, the researcher sat at the desk and a one-minute period of silence (no further owner cues being spoken) was applied to observe puppies' length of stay in front of the owner (on the mat specifically), who stood static and silent. Following this test, the owner and puppy were free to leave the test room.

2.5. Data collection

2.5.1. Cognitive tests

Test data were recorded in Belgravia, London, UK, during September - October 2021. Each puppy's entire test in each condition was recorded using three GoPro® Hero video cameras. In condition A+RO the agent's camera was facing downwards to capture the puppies' faces. In condition O+RA a camera was placed behind and to the side of the owner for the same purpose (Fig. 3). A third camera placed on a table recorded the puppies' side profiles and entire test room. Footage from the three cameras was used to extract the data.

2.5.2. Quantitative behaviour measurements

The video footage used to extract the cognitive data was edited into individual clips of each puppy's.

tests in both conditions, comprising synchronised views of the puppies' side profiles and faces to maximise the accuracy of behaviour

sampling. An ethogram from Shaw et al. (2022) utilising observations of adult dogs interacting with the agent during PRT trials was used. This was supplemented with novel behaviours seen during the current study using an inductive approach (as observed behaviour was added and defined). Gaits during approaches (walk/ trot/ gallop) aimed to determine motivational strength during approach. Positive, state behaviours ('tail wag bout', 'looking up at agent/ owner', 'cued response behaviour', 'eating food rewards' and 'close proximity post-test') aimed to measure indicators of positive anticipation, motivation to interact and persistence to continue once the agent had ceased issuing cues. No negative state behaviours were observed. Neutral event behaviours ('turn away', 'walk away', 'look to owner') were measured. Focal sampling and continuous recording (to span each clip) was used (Martin and Bateson, 1999). As test times were variable and dependent on individuals' responses, state behaviours for tests in both conditions A+RO and O+RA were recorded in seconds and converted to percentage of total test time for each condition. Event behaviours were recorded as frequency and converted to rate, standardised as per 100 s for all puppies in both conditions. Thus, data conversions allowed direct comparison between conditions when test times varied. Approach gaits were observed as one-off occurrences as each puppy made an initial approach to the owner/ agent at the start of each condition.

An additional observer (a PhD student in Animal Welfare at the University of Winchester) was recruited to enable inter-observer reliability of the quantitative measurements to be calculated. The observer had extensive experience drafting ethograms and measuring behaviour and was blind to the study's hypotheses. Eight (50%) of the video clips were chosen for analysis, to ensure all of the behaviours in the ethogram were observed. The primary author and additional observer watched the video clips an unlimited number of times and recorded the frequency of each behaviour from the ethogram (Martin and Bateson, 1999) for each video clip independently, over a one-day period during June 2023. (Table 1).

Table 1
Ethogram.

Approach gaits	Description of approach gaits
Gallop	Forward locomotion towards agent (in agent condition) or owner (in owner condition) at fast speed, forelimbs move together, hind limbs move together.
Trot	Forward locomotion towards agent (in agent condition) or owner (in owner condition) at medium speed, limbs at diagonal opposite ends of the body strike the ground together.
Walk	Forward locomotion towards agent (in agent condition) or owner (in owner condition) at slow speed, two or three feet strike the ground at any given time.
State behaviour	Description of state behaviour
Looking up	Positioned on mat in a sit, stand or down posture, head raised upwards with direct eye contact on the agent (in agent condition) and owner (in owner condition).
Cued response behaviour	Behavioural responses (correct or incorrect) to cues issued by the agent (in agent condition) and by the owner (in owner condition).
Tail wag bout	Medium or fast repetitive movement of the tail in a side to side motion at mid or high height; minimum four side-to-side motions constitute a 'bout' (both test conditions).
Close proximity post-test	Voluntary maintenance of close proximity to agent (in agent condition) and owner (in owner condition) post-test by remaining on the mat when no further verbal cues are issued; may continue to offer behaviours/ maintain direct eye contact.
Event behaviour	Description of event behaviour
Look to owner	While in front of and facing agent, turning head away from the agent to look back directly at the owner seated at the desk.
Turn away	While in front of and facing agent (in agent condition) or owner (in owner condition), turning the head to either side to look in another direction.
Walk away	From facing the agent (in agent condition) or owner (in owner condition) turning away and with forward locomotion moving away from the mat at slow or medium speed.

2.6. Statistical analysis

IBM SPSS Statistics 26 for Mac (IBM Corp, 2021) was used for statistical analyses.

2.6.1. Cognitive measurements

Data recorded in each condition were: 1. time taken to look up at the agent after it spoke the puppy's name, said 'hi' and dispensed food rewards; 2. number of recall iterations required for an approach to agent/owner; 3. time taken to start approach towards agent/owner following issue of the recall cue. 4. number of cue iterations required for each puppy to perform a correct behavioural response to each cue (maximum five iterations of a cue allowed). An incorrect response was an incorrect behaviour from the repertoire, or no behaviour (looking up without response/ walking away) within 10 s of the iteration. If no correct response was observed by cue iteration five, a fail was recorded for that cue. 5. time taken between issue of a cue and performance of the correct behavioural response. These latencies were only recorded during the cue iteration which resulted in a correct behavioural response. A puppy was determined to be latent if a time at or above 0.1 s (and subsequently measured in deciseconds as minimum units as read from a screen timer) between cue and response was recorded, and not latent if time below 0.1 s was recorded between cue and response. Total latencies and the total number of cues with latencies were recorded. Comparisons of results for each element of the tests (2–5) between the two experimental conditions were made using Wilcoxon matched pairs tests. The significance level was set to 0.05.

2.6.2. Quantitative behaviour measurements

Pearson correlations were used to calculate inter-observer reliability of each behaviour listed in the ethogram. Behaviours with high reliability (>0.7) (Martin and Bateson, 1999) were analysed further. Differences between conditions in the time spent performing each behaviour were analysed using Wilcoxon matched pairs tests. Approaches to agent/owner were scored thusly: walk = 1, trot = 2, gallop = 3. The significance level was set to 0.05.

3. Cognitive results

3.1. Agent attention and approach to agent/owner

Times taken to look up at the agent after it spoke the puppies' names, said 'hi' and dispensed food rewards ranged from 6 to 134 s ($M = 33.25$ (SD 43)). Subsequently during the two test conditions, all puppies approached the agent/owner in the relevant condition when called. In condition A+RO 7/8 puppies approached following the first recall; one puppy required a second recall iteration. In condition O+RA all puppies approached following the first recall iteration. In A+RO, one puppy was latent to approach; in O+RA, no puppies were latent to approach.

3.2. Randomised verbal cues

All puppies performed correct behavioural responses to repeated, randomised cues ('sit' and 'down') in both conditions; in A+RO, 60/64 cues and in O+RA, 61/64 cues were responded to correctly. There was no significant difference in the number of correct responses between conditions ($Z = -0.74$, $p = 0.458$). In both conditions, the success rates of the puppies were the same, in A+RO 75% of puppies and in O+RA 75% of puppies did not fail any cue. In condition A+RO the total number of fails was 4/64; two puppies failed two cues each. In condition O+RA, the total number of fails was 2/64; two different puppies failed one cue each.

No significant difference was found in the number of first choice correct behavioural responses at cue iteration one between conditions (A+RO = 46/64, O+RA = 52/64) ($Z = -0.512$, $p = 0.609$). Where correct behavioural responses or no behavioural responses were

performed at iteration one, correct responses at subsequent iterations are shown in Fig. 4.

No significant difference in the total number of times a cue was issued including those resulting in fails was found between conditions ($Z = -0.847$, $p = 0.397$).

Total latencies between cue issue and correct behavioural response were A+RO = 83.7 s,

O+RA = 31 s, significantly different between conditions ($Z = -2.243$, $p = 0.025$) (Fig. 5); median latencies were significantly different between conditions ($Z = -3.18$, $p = 0.001$). The total number of cues with latencies was significantly different between conditions, highest in A+RO ($Z = -2.207$, $p = 0.027$).

4. Quantitative behaviour results

4.1. Approach scores

Approach scores were not significantly different between conditions ($Z = -1.897$, $p = 0.058$). Approach gaits in A+RO were trot (4/8), walk (3/8), gallop (1/8) and in O+RA were trot (4/8) and gallop (4/8).

4.2. State behaviours

Interobserver reliability for the quantitative behaviours was above 0.7 in all categories as follows: Approach gaits ($r = 1.0$, $p < 0.001$), 'looking up' (0.974 , $p < 0.001$); 'cued response behaviour' ($r = 1.0$, $p < 0.001$); 'tail wag bout' ($r = 0.921$, $p = 0.001$); 'eating food rewards' ($r = 1.0$, $p < 0.001$); 'close proximity post-test' ($r = 1.0$, $p < 0.001$); 'turn away' (0.968 , $p = 0.001$); 'look back to owner' (0.933 , $p = 0.001$) and 'walk away' ($r = 0.1$, $p < 0.001$).

No significant difference in state behaviour percentages was found between conditions for the following: 'looking up' ($Z = -1.820$, $p = 0.069$), 'eating food rewards' ($Z = -1.120$, $p = 0.263$), 'cued response behaviour' ($Z = -1.540$, $p = 0.123$). Total time spent in 'close proximity post-test' was not significantly different between conditions ($Z = -0.507$, $p = 0.612$). All puppies performed these described state behaviours. A significant difference was found between the two conditions for the state behaviour percentage 'tail wag bout', highest in O+RA ($Z = -2.197$, $p = 0.028$). Not all puppies performed this state behaviour. Mean state behaviour percentages and standard deviation are presented in Table 2.

4.3. Event behaviours

Of the eight puppies, four looked back to their owners in A+RO. No significant difference in percentages of event behaviours was found between conditions; 'turn away', ($Z = -1.753$, $p = 0.08$); 'walk away' ($Z = -0.944$, $p = 0.345$) (Table 3).

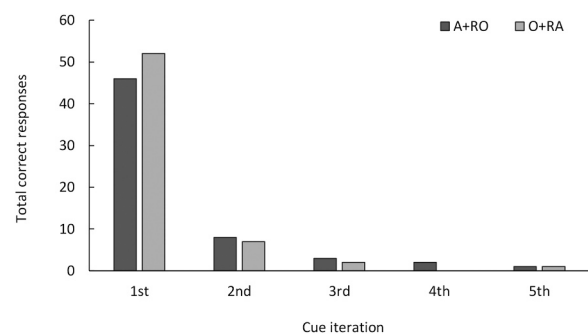


Fig. 4. Number of correct behavioural responses at each cue iteration in both experimental conditions.

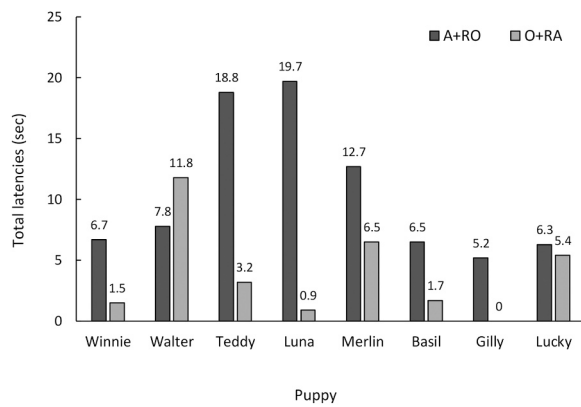


Fig. 5. Total latencies (sec) to correct responses in both experimental conditions.

Table 2

State behaviour percentage mean values with standard deviation in both conditions.

State Behaviour percentages	Condition	
	A+RO	O+RA
Looking up (at agent or owner)	31.9 (SD = 15.8)	44.9 (SD = 14)
Cued response behaviour	29.5 (SD = 5)	36.7 (SD = 8)
Eating food rewards	34.3 (SD = 11.6)	29.7 (SD = 6.4)
Tail wag bout	5.9 (SD = 12.7)	17.3 (SD = 16.7)
Close proximity post-test (total sec)	30.9 (SD = 13.6)	33.38 (SD = 19)

Table 3

Percentages of event behaviours for each puppy in both experimental conditions.

	Look back to owner		Turn away		Walk away	
	A+RO	O+RA	A+RO	O+RA	A+RO	O+RA
Winnie	2.6	N/A	0	0.9	0	0.9
Walter	0	N/A	1.5	0	0	0
Teddy	1	N/A	2.7	0	0	0
Luna	2	N/A	1	0	0	0
Merlin	0	N/A	0	0	0.8	0
Basil	0	N/A	0	0	0.7	0
Gilly	0	N/A	0	0	1.8	0
Lucky	1	N/A	4.9	3	0.6	0

5. Discussion

5.1. Cognitive results

In this preliminary study, a small group of puppies ($n = 8$) demonstrated the ability to interact with an agent comparable with interaction with their owners during the PRT paradigm. Following the agent speaking the puppies' names, the word 'hi' and dispensing food rewards, puppies took on average 33 seconds to identify the location of the speech and look directly up at the agent. These findings align to some degree with those of Ben-Aderet et al. (2017) who revealed puppies' rapid responsiveness and curiosity towards human speech emitted from a speaker. The pairing of the agent's speech with food likely facilitated a positive first impression, enabling puppies to focus and adapt to the novel paradigm. Subsequently, during the test phase, puppies were highly successful at performing correct behavioural responses to cues. These findings align with studies of adult dog-agent interaction (Shaw and Riley, 2020; Shaw et al., 2022) where a familiarisation phase had been afforded to dogs pre-testing. This phase was a step-wise, shaping process implemented to mitigate dogs' potential indicators of negative welfare in response to the agent domain. As hypothesised, this phase was

not necessary for puppies to perform correct responses; potentially due to their adaptability (Lillard, Erisir, 2011), flexibility (Foraita et al., 2021) and lack of long human-PRT histories which could potentially interfere with generalisation (new learning) to a novel context (Olsen, 2018). Puppies had only recently been conditioned to perform the two behaviours on verbal cue hence generalisation may have been easily facilitated. Adult dogs however, have not been tested without a familiarisation phase hence this should be tested in future studies.

A high percentage of first choice correct responses to the first iteration of each cue were found in both conditions, suggesting puppies were using information-based rather than guessing-based strategies (Chow et al., 2017; Olsen, 2018). In line with Shaw and colleagues' (2020; 2022) studies of adult dogs, latencies to correct responses were significantly longer in the agent vs owner condition. Furthermore, there were a significantly greater number of cues with latencies in agent vs owner condition. Owners issued their cues with no hand gestures or eye contact, but still the other owner-present (iconic and olfactory) elements remained. Although clearly puppies generalised remarkably well to the artificial context therefore, agent-interaction may have been more cognitively demanding due to a decrease in the number of clues, or sub-paths to memory (Rowe, 2005). Puppies' faster performances in the owner condition could otherwise simply relate to previous memory of success thus, expectation in that condition. Increased motivation and activation may have energised behaviour directed at attaining guaranteed, historic goals (e.g., Meehan and Mench, 2007). The findings support suggestions by Shaw et al. (2022) that any behaviour once taught to be reliable on verbal cue, could be transferred to the agent domain and in the case of puppies, rapidly. Longer-term agent exposure for example in situ (home environment) may reveal whether response latencies decrease over time as the generalisation improves and weight shifts towards online control (Toates, 2004). Further exposure may afford the opportunity to establish greater repertoires of behaviours for the agent, by owners first conditioning unimodal reliability to varied cues prior to agent transference.

For the majority of puppies, correct responses were rapidly achieved for both the 'sit' and 'down' cues. Two puppies however, required multiple iterations of the 'down' cue in the agent condition only and failed before subsequently performing correct responses. Both puppies remained in a sit or stand, looking up at the agent as it spoke the 'down' cue, or walked away from the agent before returning to receive the cue again. The multiple iterations further suggest that a great deal of processing was required to generalise this behaviour for the first time to the artificial context. These puppies performed the 'down' behaviour reliably in O+RA. Once both puppies had performed 'down' successfully for the agent, subsequent performances were also successful, hence learning was clearly evidenced during this study.

5.2. Quantitative behaviour measurement results

Overall, good welfare was maintained throughout testing as indicated by the behavioural responses of the puppies in both conditions, and no indicators of negative welfare were observed. Puppies were called by the agent or owner and could not be forced to approach or interact; approach scores aimed to reflect puppies' overarching motivation to do so. In A+RO the most common gaits were 'trot' and 'walk' and in O+RA were 'trot' and 'gallop'. While there was no significant difference in approach scores between conditions, the familiarity of the owner context would likely account for the variations in gait type seen.

Subsequently, in line with Shaw et al. (2022), no significant differences in quantitative state behaviours relating to positive anticipation and motivation ('looking up', 'cued response behaviour', 'eating food rewards') were found between conditions. The behaviours align with the phases of the pleasure cycle (*wanting, liking and learning*), suggesting pleasant experiences in both conditions. Social behaviour patterns towards the agent hence emerged and additionally, interaction was achieved as evidenced by puppies listening and performing behavioural

responses to the agent's cues. Interestingly however, a significant difference between conditions was found for 'tail wag bout', greater in O+RA. The lack of agent familiarisation may have inhibited this part of the social repertoire. Shaw et al. (2022) found no significant difference in tail wagging between agent vs owner in adult dogs, potentially as they had experienced a familiarisation-to-agent phase, but also perhaps because of greater confidence and life experience. As excitement is related to tail wagging, puppies may have been more excited in the owner domain which represents historic (though short), trusted, successful experiences. Puppies were naïve to the agent and could not have anticipated the receipt of verbal cues hence opportunity to interact. Perhaps with more exposure to the agent, puppies would express more of this behaviour, but this is speculative. As an important factor in the consideration of overall welfare during agent-interaction, tail wagging should be explored further in future puppy-agent studies. It should be mentioned that not all puppies wagged their tails in either condition, hence in line with Shaw et al. (2022) this is likely the result of individual differences.

Post-test, in both conditions, all puppies remained on the mat for an average 3s, looking up and/ or offering further behaviours, which implies motivation to sustain interaction. Puppies then moved away to explore the room, drink some water from the bowl, or investigate the A+RO or O+RA mat depending on condition. This perhaps provides some potential insight into home application; when the agent was no longer active after a short period, puppies walked away.

Event behaviours were rare; 4/8 puppies looked back from the agent to their owners, a behaviour shown to occur when adult dogs are unsure how to solve a problem for example in 'impossible tasks' (Miklósi et al., 2003). In the current study, owners were instructed not to give the puppies any feedback, visually or verbally, hence puppies subsequently made their own behavioural choices. It could also be argued that puppies were looking back to owners to determine the source of the verbal cues (owner vs agent) since they were naïve to the agent context. Throughout testing, some puppies appeared distracted, particularly following the more challenging 'down' cue, as discussed previously, hence 'turn away' and 'walk away' behaviours were recorded, primarily for two puppies. One puppy barely looked up at the agent or owner during testing; he may have been lacking confidence or was just not equally engaged visually as auditorily.

In summary, the majority of quantitative behaviour measurements relating to positive anticipation and motivation in this study align with those found in adult dogs (Shaw et al., 2022), and no indicators of negative welfare were identified. Tail wagging was significantly greater for owner vs agent, and this may or may not change over time with further agent exposure and could indicate a less enjoyable experience during agent vs owner interactions. Overall, puppies remained at the agent post-test for as long as they did with their owners post-test, suggesting that interaction would have been voluntarily prolonged if the agent had remained active. Given these results, it is plausible to suggest that the agent may represent a potential form of cognitive enrichment for puppies.

5.3. Limitations

In line with much of the cognitive enrichment literature, the sample size in the present study was small ($n = 8$) and a larger group may reveal more variability both cognitive- and welfare-wise. It was hypothesised that if puppies met the testing criteria, they would be successful at agent interaction based on the authors' adult dog research. In other words, if behaviours had been conditioned unimodally on verbal cue using PRT with food as the reinforcer, generalisation to the agent would most likely occur and this was found to be the case. Following the testing of puppy number eight therefore, no further data were collected. The study aimed to answer the core questions posed (can puppies interact? Do they need a familiarisation phase? Are they motivated to interact?) and this is considered to have been achieved. While the sample was small, as the

first study (as best known to the authors) to evaluate domestic dog puppies' interactions with an artificial agent, the results have provided meaningful preliminary data and a rationale for further testing. It would be interesting to test younger puppies in the primary socialisation phase (under 12 weeks), to establish the viability of introduction during this period. However, as an artefact of the recruitment process, puppies participated after joining puppy school hence were on average in the 16-week range by the time reliability of behaviours on verbal cue was established. As unimodal conditioning is not typically included in formal curriculums (Kennel Club, 2023), the sample may not represent the typical broader puppy population. The puppies in this study were, however, highly useful to demonstrate the theoretical capability of a wider and more diverse sample which should be evaluated in future research.

The order of conditions was the same for all puppies; agent condition followed by owner condition. This was considered to be a logical progression from the attention phase to the agent-interaction condition. Applying this method however, puppies may have been more motivated to interact due to novelty than if baseline then been provided first. In other words, puppies hypothetically could become fatigued by baseline testing, and responses to the agent may have been poorer if baseline was the first condition. Conversely, providing baseline first might have given the puppies a 'warm-up' enabling better performance for the agent as condition two. Future studies with larger samples could apply a counterbalanced design to determine any order effects.

While positive welfare was maintained throughout testing and no negative welfare indicators were observed, further studies are recommended to facilitate comprehensive welfare assessment. Larger samples afforded agent-interaction over the longer-term may reveal potential welfare impacts (positive or negative) or lack thereof as a direct result of extended usage.

5.4. Conclusion

In the present study, eight puppies demonstrated the ability to respond correctly to two, randomised and repeated verbal cues ('sit' and 'down') issued by an artificial agent. No significant difference in correct responses to cues was found between owner vs agent conditions. Puppies did not require a familiarisation-to-agent phase, responding to its cues after attentional focus had been achieved. Latencies to respond were significantly longer for the agent condition than baseline, suggesting the requirement for increased cognitive control in the agent context. Some puppies required several iterations of the 'down' cue to perform it correctly hence learning was evidenced during the test period. Quantitative behaviour measurements relating to positive anticipation and motivation were identified throughout testing, indicative of the maintenance of positive welfare in both conditions, and no indicators of negative welfare were observed. Tail wagging, however, was significantly greater for the owner condition; this element of the behavioural repertoire may require further time to develop in the artificial context as seen in adult dogs. All puppies remained at the agent post-test suggesting motivation to prolong interaction. The study is the first to investigate puppies' interactions with a positively reinforcing artificial agent, providing support for ongoing research of automated (AI) training technologies which aim to augment early learning and potentially afford longer-term enrichment.

CRedit authorship contribution statement

Nicky Shaw: the conception and design of the study, or acquisition of data, or analysis and interpretation of data, drafting the article or revising it critically for important intellectual content. **Lisa M. Riley:** the conception and design of the study, or acquisition of data, or analysis and interpretation of data, drafting the article or revising it critically for important intellectual content.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: The lead author, Nicky Shaw, filed a UK patent in July 2013 titled “A pet interaction device” and this patent was granted to the author in November 2018, patent number: GB2512674. No product in relation to the patent owned by the author currently exists nor is in development to the author’s best knowledge. The author does not own any other patents nor has filed any further patents to date. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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